COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

ELECTRONICS RESEARCH LABORATORIES

632 WEST 125th STREET
NEW YORK, NEW YORK 10027

THE FLUID TRANSPIRATION ARC AS A RADIATION SOURCE FOR SOLAR SIMULATION

SEMI-ANNUAL PROGRESS REPORT P-4/312

AFOSR-68-0762

July 1, 1967 to December 31, 1967

1 MAR 1968

1. This document has been approved for public release and sale; its distribution is unlimited.

ERL

COLUMBIA UNIVERSITY

IN THE CITY OF NEW YORK

ELECTRONICS RESEARCH LABORATORIES

632 WEST 125th STREET

NEW YORK, NEW YORK 10027

THE FLUID TRANSPIRATION ARC AS A RADIATION SOURCE FOR SOLAR SIMULATION

SEMI-ANNUAL PROGRESS REPORT P-4/312

AFOSR-68-0762

July 1, 1967 to December 31, 1967

1 MAR 1968

by

C. Sheer

S. Korman

ERL

Prepared for
Mechanics Division
Air Force Office of Scientific Research
1400 Wilson Boulevard
Arlington, Va., 20333

Contract AF 49(638)-1395
Project Task 9783-02

PRECEDING PAGE BLANK NOT FILMED.

FOREWORD

This semi-annual report was prepared by staff members of the Plasma Engineering Laboratory of the Electronics Research Laboratories, Columbia University, New York, N.Y., under contract AF 49(638)-1395, for the Mechanics Division, Air Force Office of Scientific Research, Office of Aerospace Research, USAF. The work is being performed under Project-Task 9783-02 and is under the technical cognizance of Mr. Paul A.Thurston, SREM, of the Mechanics Division, AFOSR.

This contract is jointly supported by the Office of Advanced Research and Technology, National Aeronautics and Space Administration, under the cognizance of Mr. Conrad Mook.

Acknowledgments are made to Mr. William Henriksen for his invaluable mechanical designs and to Messrs. Vito Fiore, Mark Gelband and Nestor Santiago for their assistance in carrying out the experiments. The authors are also grateful for the cooperation and assistance of the technical staff of the Electronics Research Laboratories, under the direction of Prof. L. H. O'Neill.

ABSTRACT

This report covers the period July 1, 1967 to December 31, 1967, and is the second in the series of progress reports on a project to develop the fluid transpiration arc as a radiation source for solar simulation. Continuing with the co-linear opposing flow geometry of the two electrode columns, a complete module has been designed, constructed, assembled and instrumented for operation and for analysis of radiation and energy dissipation. Work was also begun on assembly of spectral irradiance instrumentation.

Preliminary testing disclosed two basic problems, requiring effort directed toward auxiliary development. These problems were (1) maintenance of the integrity and porosity of the tungsten porous anodes, specifically to avoid destruction or deterioration of the surface by melting; (2) the need for a porous tungsten anode design which would ensure that all of the gas metered to the anode would enter the arc discharge--a requirement which was particularly acute at pressures above atmospheric. Both problems were successfully solved and the results incorporated into the program. In particular, the first problem was solved by introducing circuitry which would control the arc ignition transient current level. The second problem was solved by shrink-fitting the porous slug into a precision-bored copper holder; when properly done, this eliminated edge-leaks.

AUTHORIZATION

The work described in this report was performed at the Electronics Research Laboratories of Columbia University. The report was prepared by C. Sheer and S. Korman.

This project is sponsored by the Mechanics Division, Office of Aerospace Research, Air Force Office of Scientific Research, and jointly sponsored by the Office of Advanced Research and Technology, National Aeronautics and Space Administration, under Air Force Contract AF 49(638)-1395.

Submitted by:	Approved by:
Charles Sheer Laboratory Supervisor	For L. H. O'Neill Professor of Electrical Engineering Director

TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

This report is the second in a series of semi-annual progress reports describing the work done on applications of the FTA (Fluid Transpiration Arc). It covers the period July 1, 1967 to December 31, 1967. The application under way at present is the development of an efficient radiation source designed specifically for improved performance in solar simulation.

The first report (Ref. 1)* dealt primarily with background, design, and procurement. Also described in that report are the results of an experiment embodying a new concept for an arc plasma radiation source. This consists of a colinear arc configuration, as in the short arc lamp, but operated with gas flow such that both electrodes are regeneratively cooled, the anode by transpiration cooling, and the cathode by gas film cooling of the conical surface, with the aid of an annular nozzle. The two opposing jets collide in the center of the gap, creating a large stagnant zone of luminous plasma in the arc conduction column. This configuration is sketched in Fig. 1 (taken from Fig. 8, pp. 25, of the previous report (Ref. 1)). The preliminary experiment (at 1 atmosphere of argon) was sufficiently promising to warrant the adoption of this configuration in place of the conical configuration shown in Figs. 3 and 4, pp. 7 and 8, of the previous report (Ref. 1) originally considered.

In consequence, a large part of the effort during 1967 was devoted to design, construction and assembly of the new lamp,

---

* "The Fluid Transpiration Arc as a Radiation Source for Solar Simulation," Semi-Annual Progress Report P-3/312, AFOSR 67-2363 January 1-June 30, 1967.

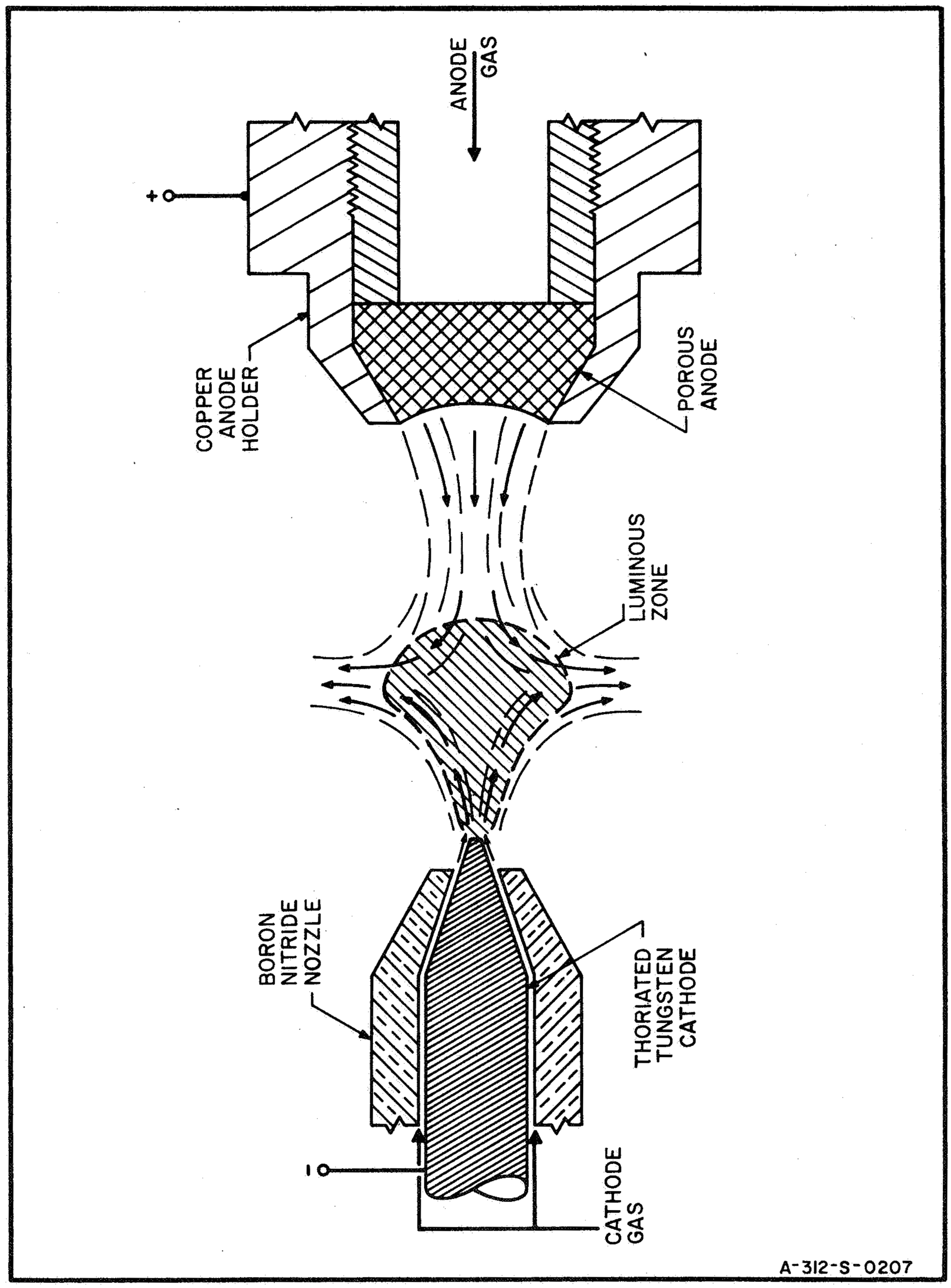

FIG. 1 SKETCH OF COLINEAR OPPOSING FLOW RADIATION SOURCE

its housing, control console, and auxiliary instrumentation, including radiometric apparatus. In addition, auxiliary programs on the automatic arc ignition system and the development of an optimum porous tungsten anode were carried forward with success.

II. PROGRESS TO DATE

For the purpose of reporting, the progress made during the second half of 1967 is divided into two areas. The first involves design, construction, assembly and unit tests of the (colinear) source and its associated instrumentation. The second area is concerned with auxiliary developments in support of the main program.

A. DESCRIPTION OF THE SOURCE AND ASSOCIATED INSTRUMENTATION

The total assembly of components involved in the development of the new source includes the following:

1. The arc source and its housing.
2. Power supply, arc igniter, and arc control system.
3. Energy sinks and instrumentation for measuring energy received; this includes:
   a. Gas recirculation system,
   b. Cooling water systems,
   c. Calorimeter for measuring radiant energy output of the source,
   d. Thermocouple system and readout.
4. Radiometry instrumentation, for measuring spectral irradiance and distribution of intensity.

Each of these components will be described and illustrated, in turn.

B. AUXILIARY DEVELOPMENTS

Throughout the period reported on herein, both during the design and assembly as well as the test work, the need for auxiliary development work became evident, as a second area of work, in support of the main program. These developments led to the solution of two basic problems which were disclosed in the initial test:

1. Maintenance of the integrity and porosity of the tungsten anode. Early trials indicated that the major problem was to avoid melting of the anodes, with consequent closure of the porous surface. Initial tests showed that this could be prevented provided knowledgeable attention is paid to the arc ignition transients. These were found to play a profound role in achieving steady operating conditions with no damage to the anode, a problem hitherto identified with the FTA as well as other types of sources currently in use or under development.

2. The achievement of a porous tungsten anode design which would ensure that all of the metered gas delivered to the anode would indeed enter the discharge; this became particularly evident as a problem to be overcome as the initial test work proceeded to pressures above atmospheric.

Both problems were adequately met by the auxiliary development program to the extent attained by the end of the report period. The details will be described below. Further improvements, currently in evolution during the present test program, will be roported upon later.

Figures 2A and 2B are photographs showing the assembly of instruments and controls to the entire system, with the exception of the power supply, which is a Miller 60-kw silicon rectifier unit, model SR-1000-C7. In Fig. 2A, the control console provides the operator with power controls for ignition, current, gas metering to anode, cathode, and sweep gas surrounding the arc and and inter-envelope pressurization of the double quartz housing. Also provided are precision metering valves, flowmeters, pressure gauges, cooling water circulation systems, with their

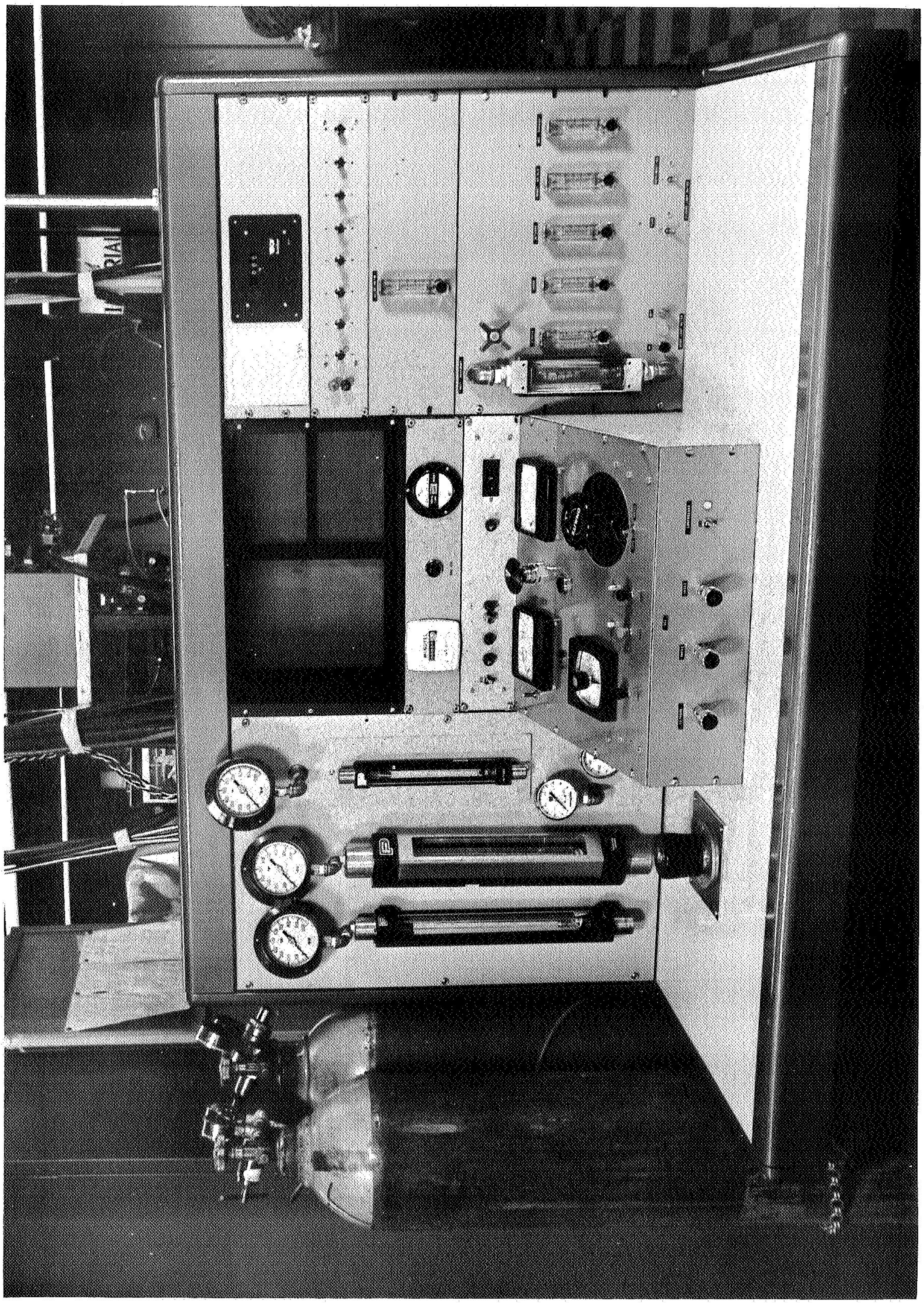

FIG. 2 A PHOTOGRAPH OF MODULE CONTROL CONSOLE

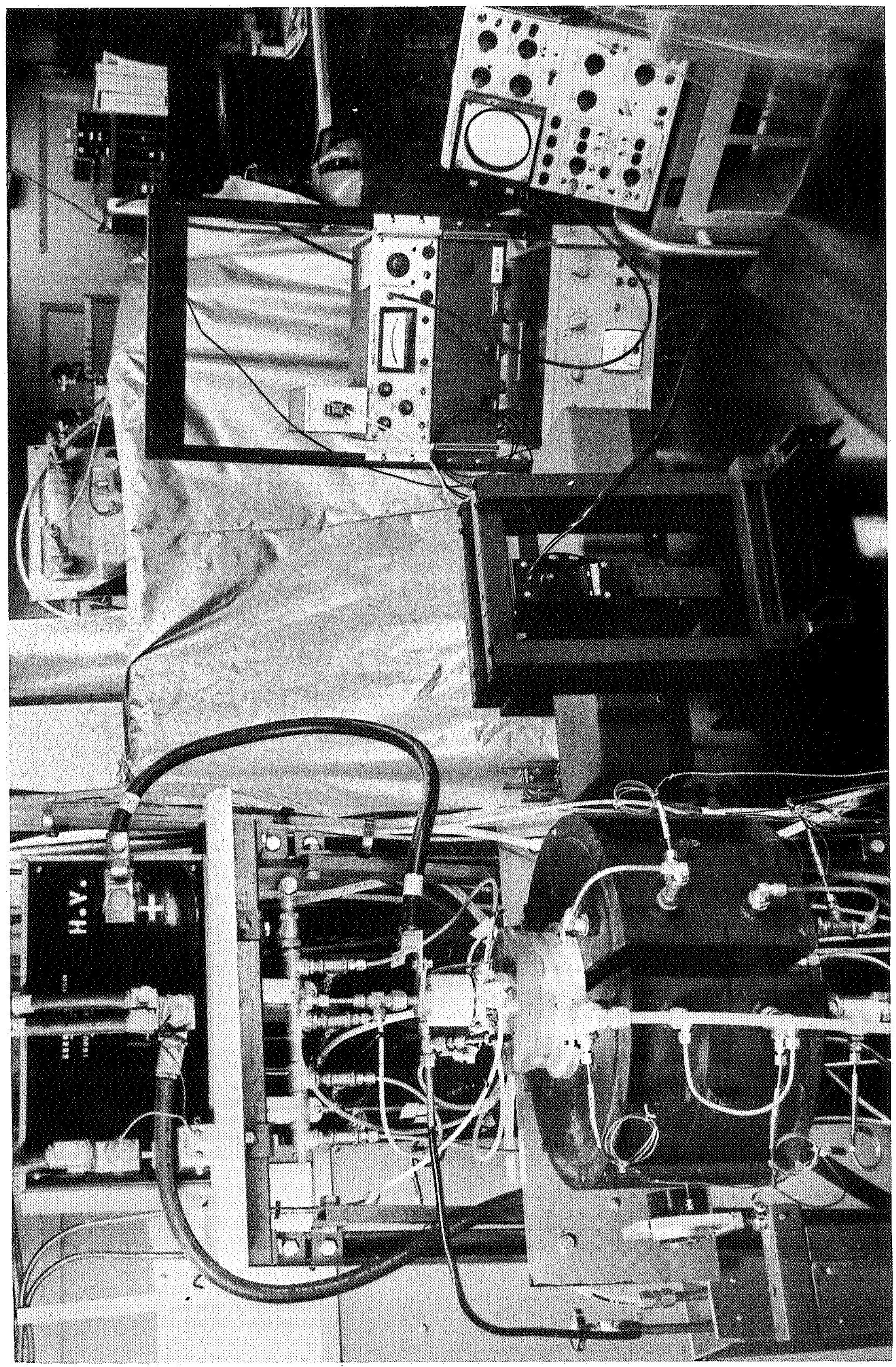

FIG. 2B PHOTOGRAPH OF SPARK IGNITER UNIT, CALORIMETER CONTAINING ARC SOURCE, AND RADIOMETRY INSTRUMENTATION associated valving and flowmeters, thermocouple selection panel and direct reading temperature unit. The operator is provided with a ground-glass screen for direct viewing of the arc magnified about 5X through a 1/8" diameter hole and a single convex lens aligned with the arc gap, the electrodes, and the center of the screen. Provision is also made for future optics for close-up viewing of the anode and cathode surfaces. The control console also contains a laboratory Cenco pump for evacuating the system prior to back-filling with argon gas through a Marotta gas regulator situated on the console table, connecting a tank of argon for automatic pre-set pressure maintenance. This valve bleeds gas in if the pressure drops below the pre-set value, and will also vent if a sudden pressure rise above that value is experienced. It is connected to the system at the intake of the gas compressor unit, which is also inside the control console.

Figure 2B shows the structural frame behind the console, bearing the arc source inside the calorimeter, with a 75,000 volt spark igniter unit, (Engelhard - Hanovia Model Z-1750 1000 amp starter) directly above the arc unit and calorimeter.

On the right of Fig. 2B will be seen the radiometry apparatus, which includes a Leiss monochromator with associated light chopper and spectral detection units to be described below.

1. <u>Source: Details of Construction</u>

Figure 3 is a sketch of the most recent modification of the arc source assembly, while Figs. 4 and 5 are exploded and assembled views of the unit, respectively. While the overall design of the original unit has not been changed, certain modifications became necessary when initial test work was undertaken:

a. Flat, rather than concave, surfaced porous tungsten anodes are being used, for the present. While some focus-

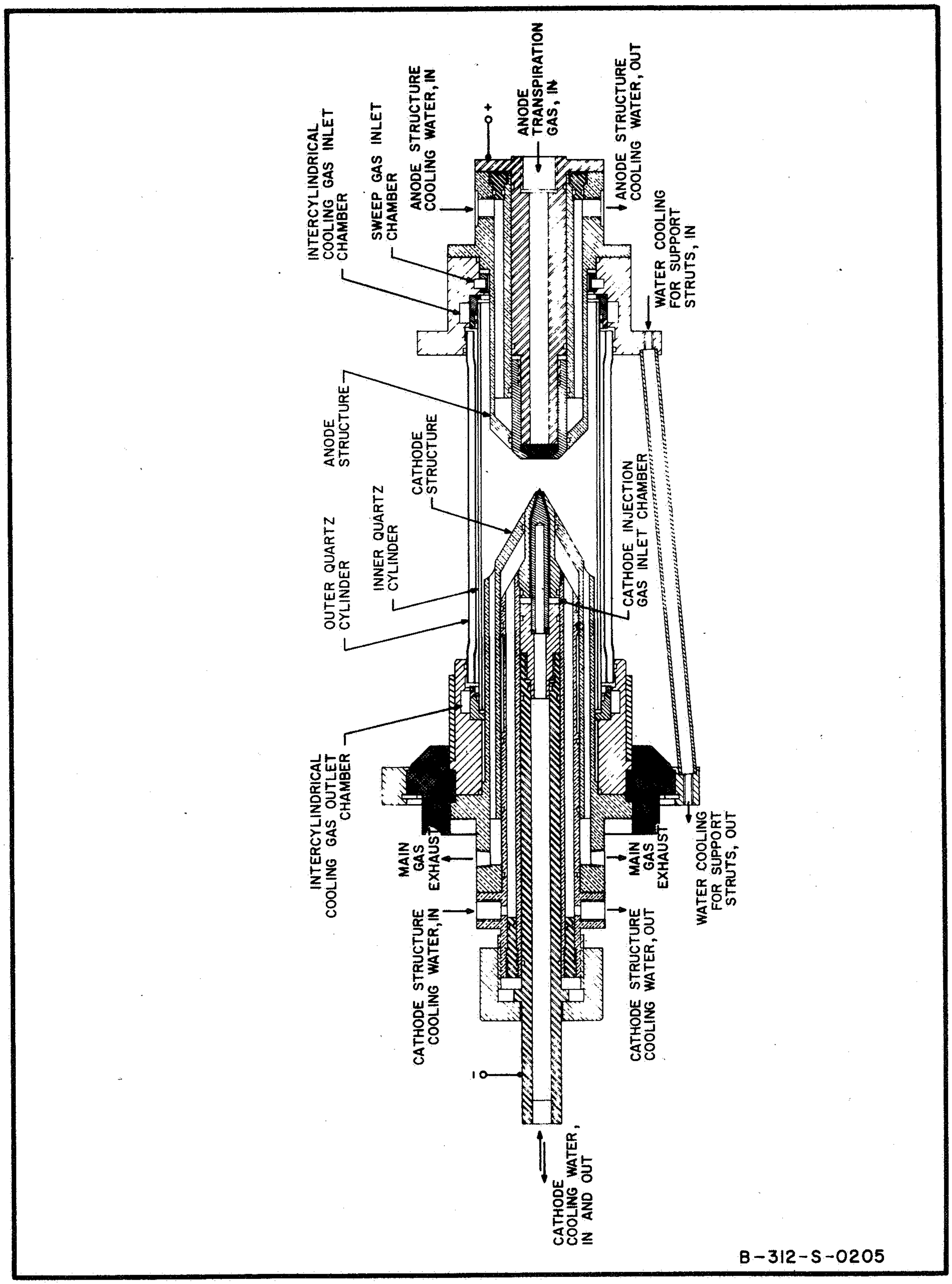

FIG. 3 ASSEMBLY SKETCH OF MODIFIED OPPOSED GEOMETRY
FTA RADIATION SOURCE

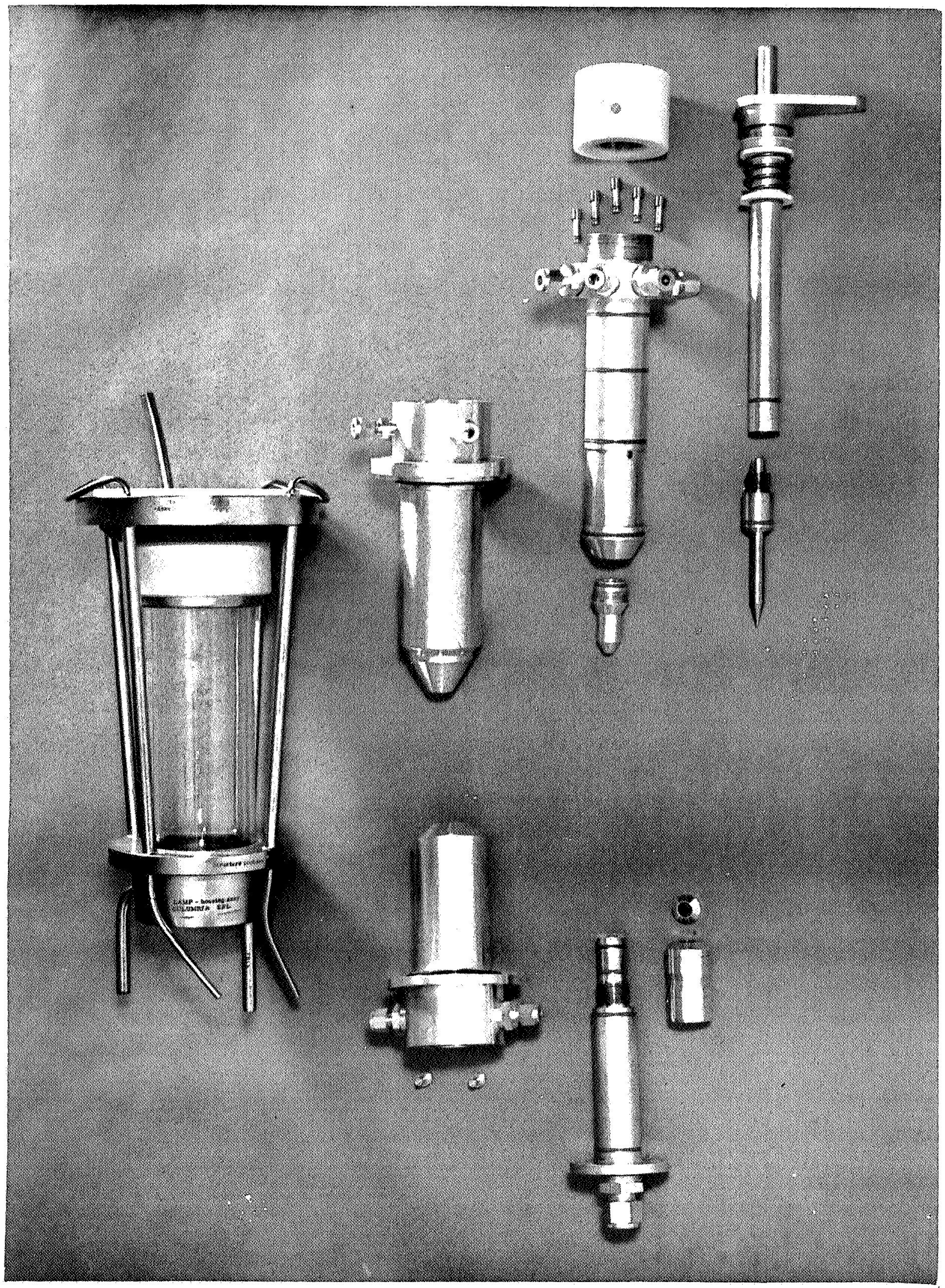

FIG. 4 EXPLODED PHOTO OF ARC SOURCE UNIT

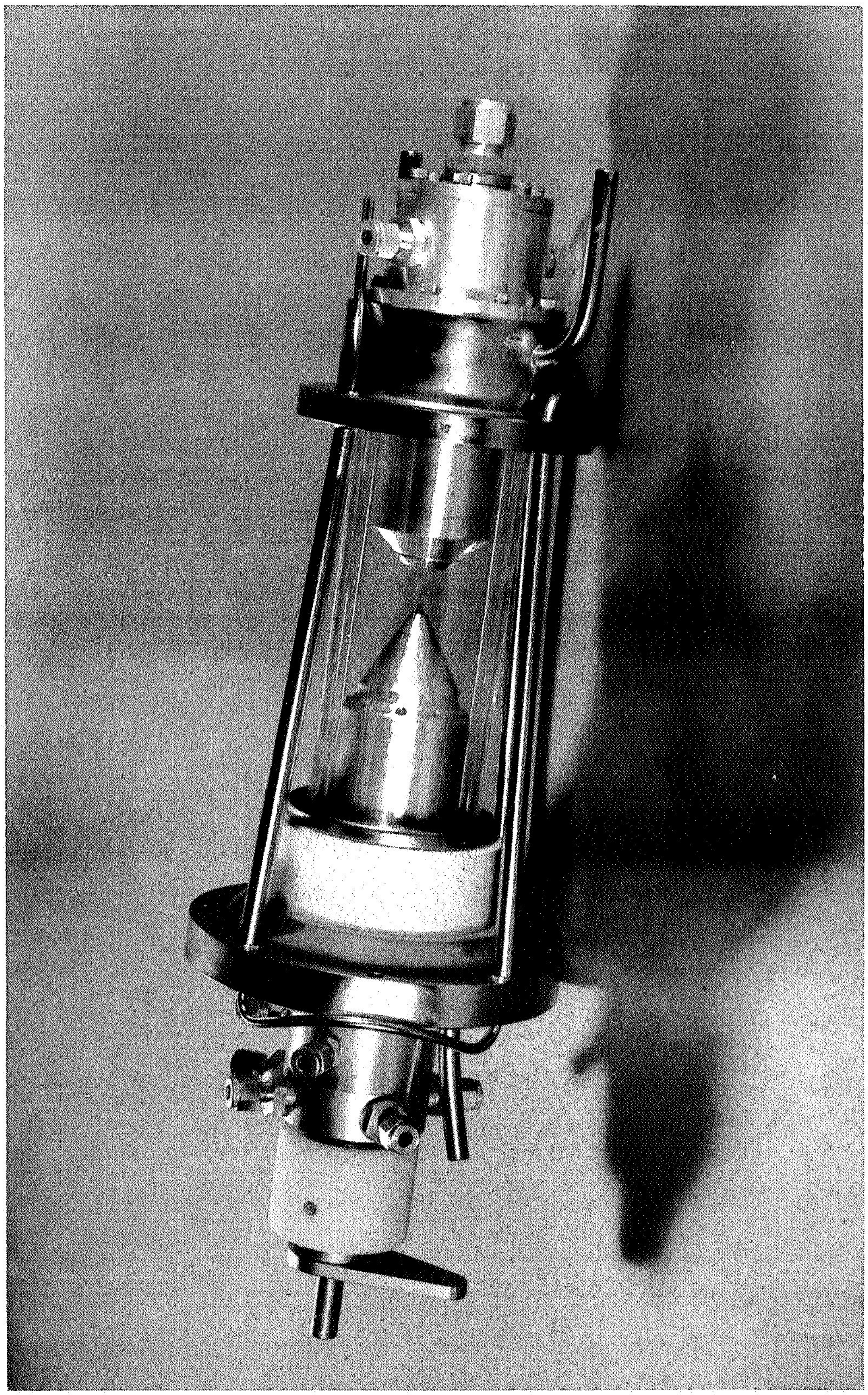

FIG. 5 PHOTO OF ASSEMBLED ARC SOURCE UNIT

ing of the anode transpiration gas may ultimately prove desirable, present technology of fabrication of these anodes is somewhat limited and under current study for other reasons, so that in order to avoid undue delays in getting initial operating data, the simplest form of anodes was used.

b. The high voltage igniter was selected to provide a spark breakdown between the electrodes with a spacing of 15 mm* at the projected starting pressure (100 psi). This requirement posed the secondary problem of preventing breakdown external to the lamp between structural members at anodic and cathodic potential, respectively. A spark ignition outside the lamp could produce an arc discharge with catastrophic consequences for the entire structure. Therefore, the apparatus was reviewed to find all external places where a gap of small dimensions might exist between the cathode end assembly and the remaining structure which is at anode (ground) potential, so that these locations could be effectively insulated against accidental external arcs during ignition with the main power on. One such location is the water-cooled support struts connected electrically to the cathode housing. A glass-impregnated Teflon ring was machined and slipped tightly over the cathode housing base structure at the quartz envelope insert. Elsewhere on the unit, exposed parts found to form spark-over locations were covered with silastic insulation, until no further undesired sparking could occur.

2. <u>Gas Circulation System</u>

Figure 6 is a schematic diagram of the gas circulation system, using tank argon as a working fluid. There are three separate gas circuits in this system:

a. Anode gas circuit. This gas comprised the main working fluid for the arc discharge. It is injected under pres-

* As a result of preliminary tests this value is being reduced to 11 mm and parts of the lamp are being redesigned to make the gap somewhat adjustable.

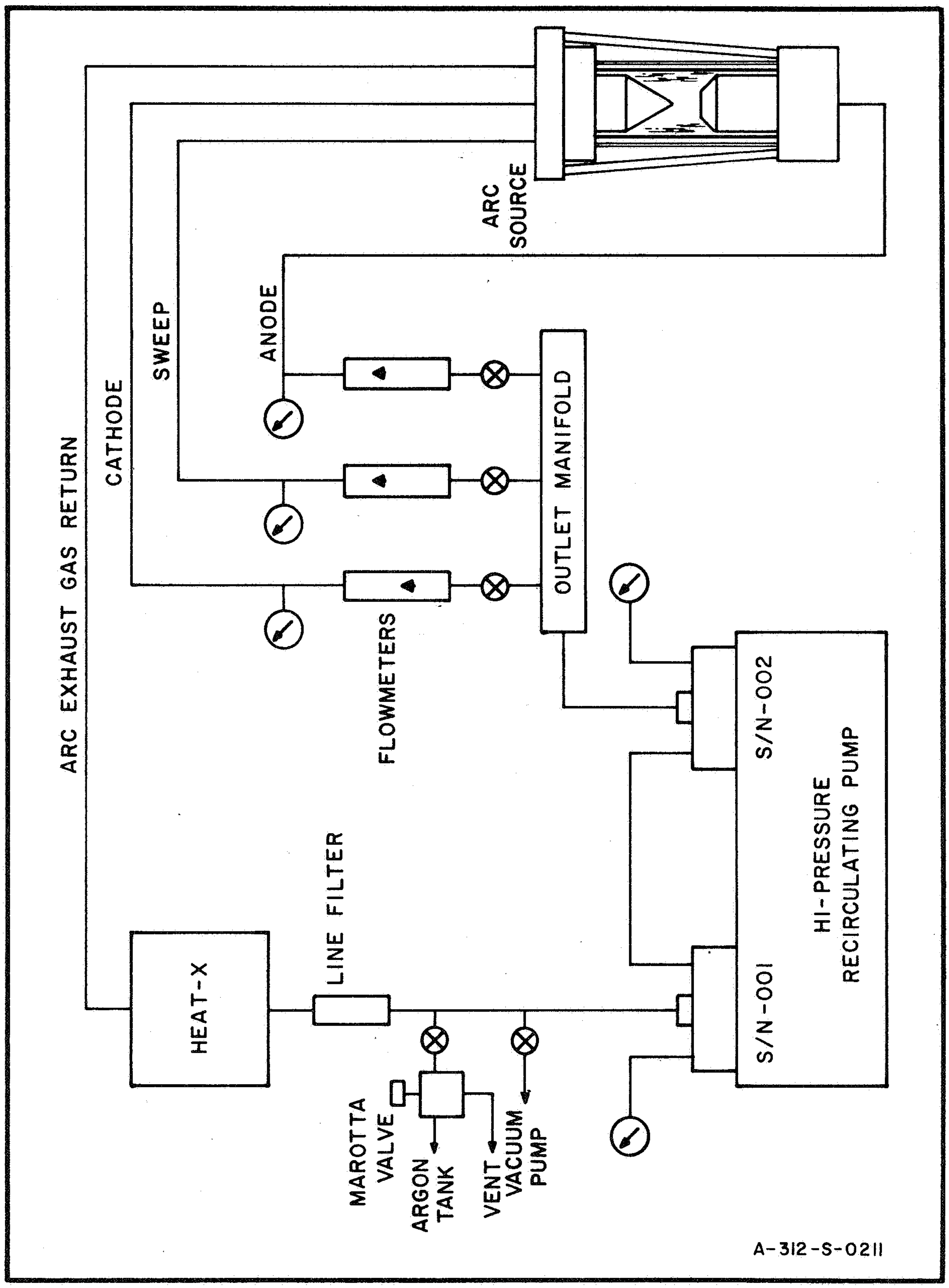

FIG. 6 FTA RADIATION SOURCE GAS FLOW SCHEMATIC DIAGRAM

sure at the back face of the porous anode and performs the double function of transpiration cooling of the anode and feeding ion-rich plasma into the radiation zone in the column.

b. Cathode gas circuit. The gas in this circuit is injected into the column via an annular concentric nozzle surrounding the tapered end of the cathode. It also performs a double function, both cooling the cathode tip by convective film heat transfer, and enhancing the brightness of the column at the cathode end of the discharge. The cathode jet ultimately collides with the anode jet, forming a high brightness stagnant zone in the center of the column, (see Fig. 1). After merging in the column, the anode and cathode jets flare radially outwards to the exhaust parts.

c. Auxiliary sweep gas. The gas in this circuit is first fed into the intercylindrical space between the two quartz cylinders where it neutralizes the pressure drop across the inner cylinder and cools both cylinders, maintaining a low thermal gradient across the outer (load-bearing) cylinder. After leaving the inter-cylindrical passage,it is then fed tangentially into the chamber itself causing a vortex flow. This helps to keep the inner surface of the inner cylinder clean of possible arc debris and serves to temper the arc effluent, lowering the gas temperature before the combined streams enter the arc exhaust ports. The vortex motion also helps to stabilize the discharge on the axis of the lamp.

The exhaust gas is then sent through a water-cooled heat exchanger and line filter to the intake of the gas compressor. After recompression, the gas is distributed into three streams feeding the anode, cathode, and sequential inter-envelope and sweep circuits, respectively,through a distribution manifold. Control is maintained by setting micrometer precision needle valves into calibrated flowmeters and pressure gauges, situated on the control console, so that flow rates may be conveniently monitored.

Two major components of the gas circulation system deserve special description:

d. Gas compressor: Model 106 Centrifugal Pump, Tamarack Scientific Company Inc., Orange, California.

This unit is a two-stage centrifugal compressor, designed to operate from 400 cycle, 200 volt, three-phase power supply to each of two motors, one per stage, and a small cooling fan. The rotors at full speed move at 22,800 rpm, receiving argon at a maximum of 300 psi, and delivering up to 18 SCFM at 410 psi to the recirculation line manifold.

e. System pressure regulator: Marotta Valve Company Regulator Model RV-23, Boonton, N.J.

This device is installed between the argon gas reserve tank and the return line to the inlet side of the compressor. It can be pre-set to regulate at a given pressure which is thus monitored continuously. In this system, if the pressure falls below the pre-set value, which is also hand-adjustable during operation, the regulator opens to admit more argon until the pressure is restored. If there is a sudden surge the regulator immediately vents itself to the atmosphere, holding the pressure to the pre-set value. The system can also be dumped very rapidly by hand-venting the regulating adjustment handle on the console.

When modifications are to be made for operation with xenon gas in place of argon, the entire gas circulation system would be reduced to minimal volume, and the Marotta regulator vent port would be connected to the xenon gas reservoir; this would be a bladder arrangement, entirely closed, but subjected to modulation by an expendable gas, such as air or nitrogen on the external side of the bladder at an over-riding pressure to drive the xenon into the system if the Marotta valve opens to bring the pressure up, but at a pressure low enough to permit return of xenon through the vent port if the pressure in the system exceeds the pre-set value. The Marotta valve also has an adjustable safety vent, which acts as a relief port, should the pressure suddenly rise beyond the venting value and endanger the flowmeters; this is in lieu of a rupture disc.

Water Circulation System

The purpose of the water circulation system is basically two-fold:

1. Withdraw a minor amount of heat to avoid damage to critical structural portions of the source assembly which are exposed to intense heat:

2. Absorb energy for the determination of the distribution of energy dissipation. Thus, the flow rates and temperature rise of various portions of the assembly are monitored.

Two separate water systems were installed. One is a closed loop of refrigerated, de-gassed de-ionized water, which serves the arc source anode and cathode assemblies. The other is an untreated open system drawn from the building water supply, with independent pumping and pressure control. This system cools the the source housing structure, the segmented calorimeter, the exhaust gas heat exchanger, and the cooling coils of both stages of the compressor.

Figure 7 is a schematic diagram of each water system.

Figure 8 is a schematic diagram of the segmented calorimeter. Water flows in sequence through each quadrant of this unit, with thermocouples for measuring the temperature rise in each segment. In this way, it is possible to determine the spatial distribution of the total radiant energy leaving the source.

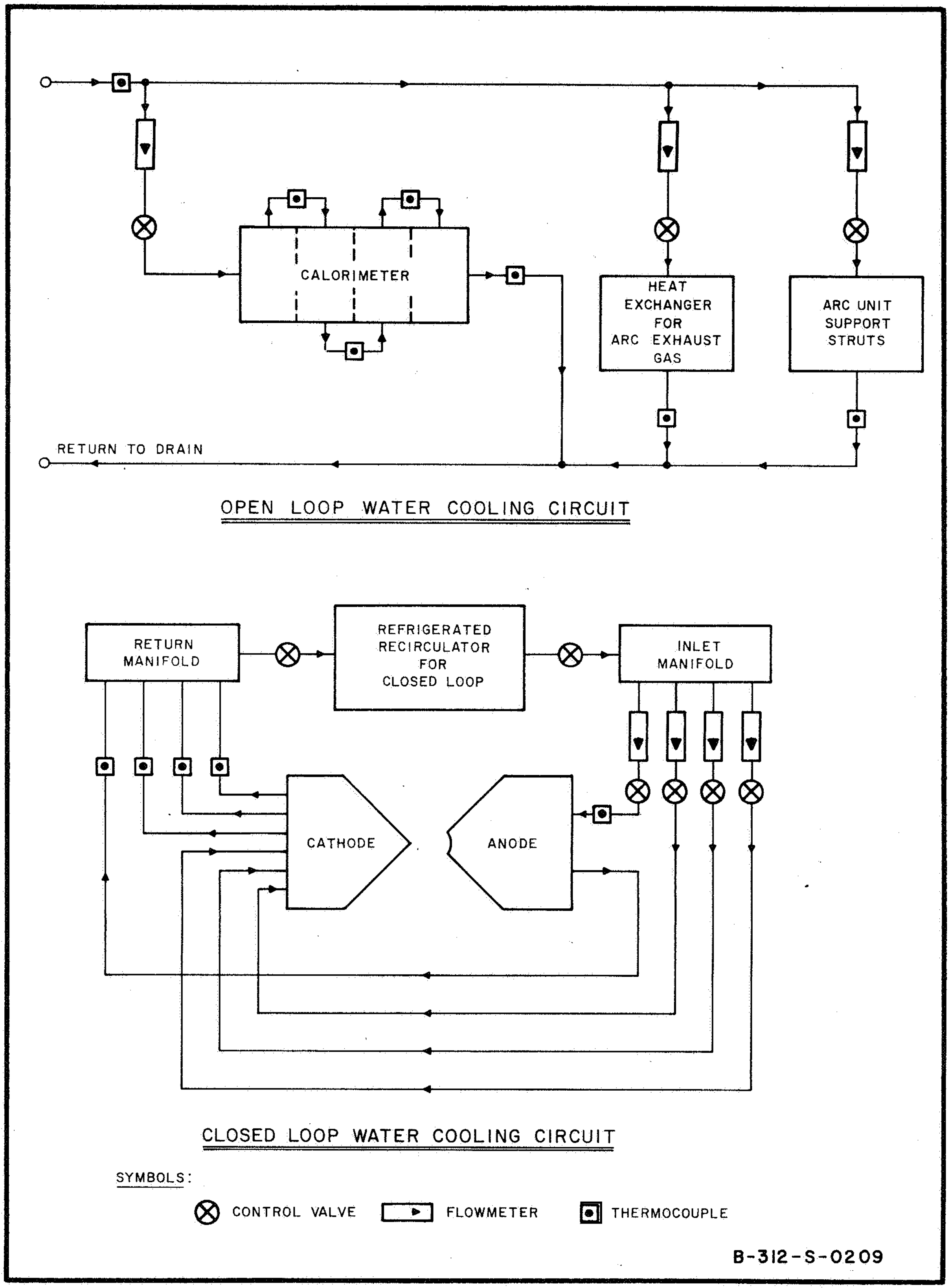

FIG. 7 WATER COOLING CIRCUITS FOR FTA RADIATION SOURCE

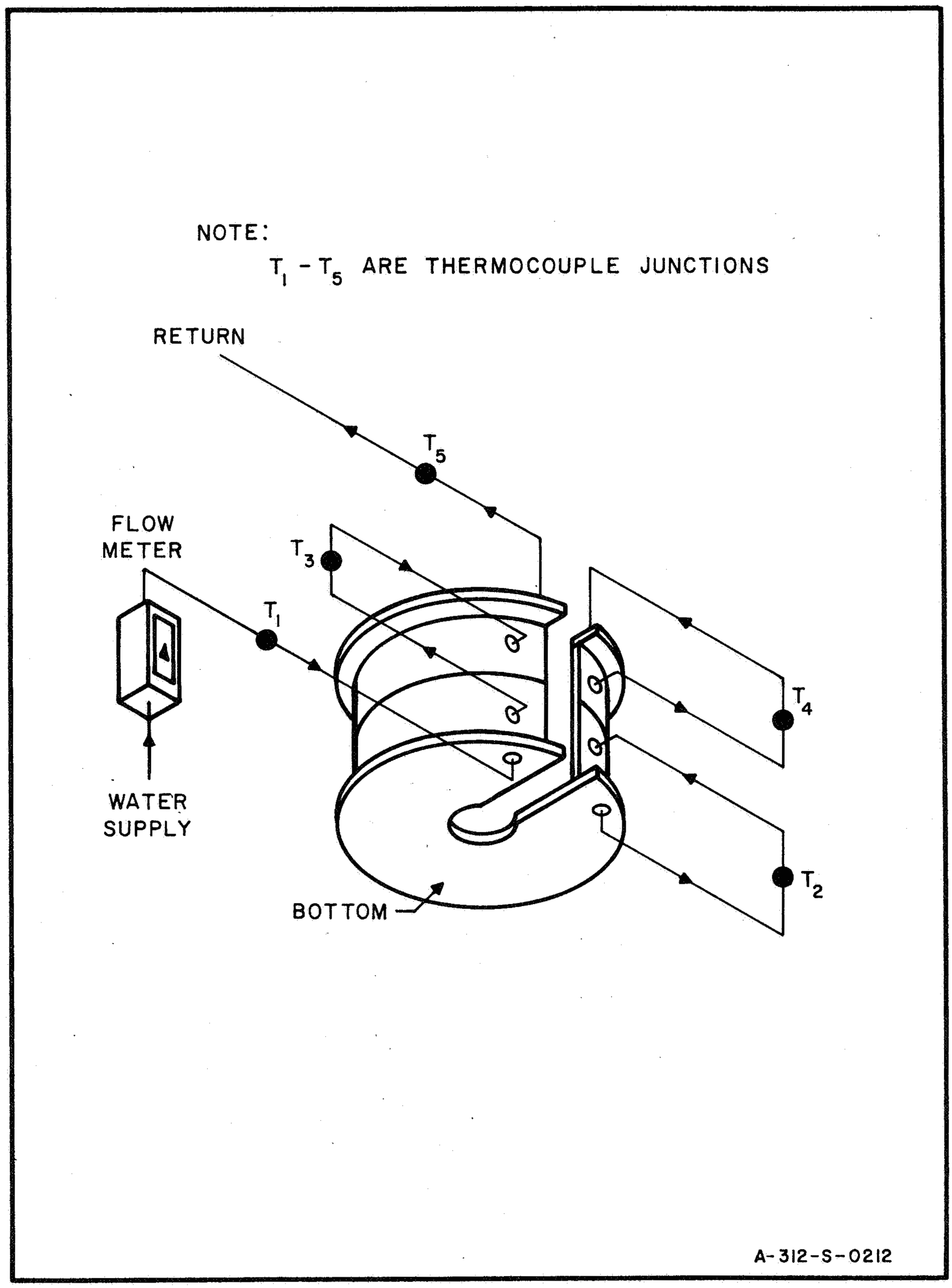

FIG. 8 SCHEMATIC-SEGMENTED CALORIMETER

Arc Control System

As indicated earlier in this report, a basic consideration in ensuring the reliability of operation of the FTA arc source, over long periods of time, includes the insurance that the anode will not melt as a result of exposure to the large current densities required for effective operation. Adaptation of knowledge gained from the auxiliary development program during this report period developed the required information which made it clear that this condition could be achieved.

In work which had been started before the onset of the source program, but which was carried through mainly during this period, (and which will be reported in detail in another technical note to AFOSR) it became apparent on close study that the condition which produces melting of the tungsten anode surface, as well as erosion of the porous graphite anodes which preceded it in this project, begins during the arc ignition, in the following way:

Immediately after the igniter is turned on and a spark is discharged across the gap, i.e., during the transition from a spark to an arc, the discharge forms a small terminus on the surface of the porous anode. This terminus is the area of entrance of the arc current from the discharge into the anode proper. This laboratory has observed that, with conventional power supplies and ignition systems, between the moment of spark discharge and the advent of steady state arc current level, the current undergoes a very large surge, in tests on the scale of interest here, a steady state current of, say, 100 amperes or more. Furthermore, this transititional phenomenon requires several seconds before it subsides to the pre-set operating current level.

At the same time that this occurs, the arc terminus on the anode surface likewise takes several seconds to grow from the small initial spot area to the operational area for the desired current density. Thus, for a relatively large period at the time of ignition, a transient situation exists in which the anode is subjected to a very high energy input over a very limited fraction of its surface. The dissipation of this energy is, we have found, not sufficiently rapid, and as a result, the anode material locally receiving this energy becomes overheated to such a degree that, in the case of tungsten, the surface layer melts; in the case of porous graphite, which does not melt, the surface undergoes erosion of the bond bridges which join the graphite particles into a porous network, causing fragmentation of the local overheated anode area.*

Analyzing the causes of anode deterioration in the case of the FTA, the conclusion was reached, therefore, that, provided an operable balance was maintained between energy input and transpiration gas throughput, lifetime and reliability depended upon eradication of the ignition transient phenomenon. This was accomplished by introducing circuitry which would permit controlled current increase during the transient period, starting from minimum current and avoidance of the transient surge above the steady state level, while maintaining adequate transpiration gas flow throughout.

This turned out to comprise a successful solution to the problem, and the circuitry is shown in Figs. 9 and 10. Figure 9 is a schematic diagram in which the important addition consists of a bank of several one-ohm by-pass resistance shunts, carrying over-load currents during the ignition period. The number of such shunts introduced into the circuit determines the minimum

---

* It is the writers' belief that the same phenomenon causes pitting on the anode surfaces of other types of arcs utilizing water-cooled solid anodes.

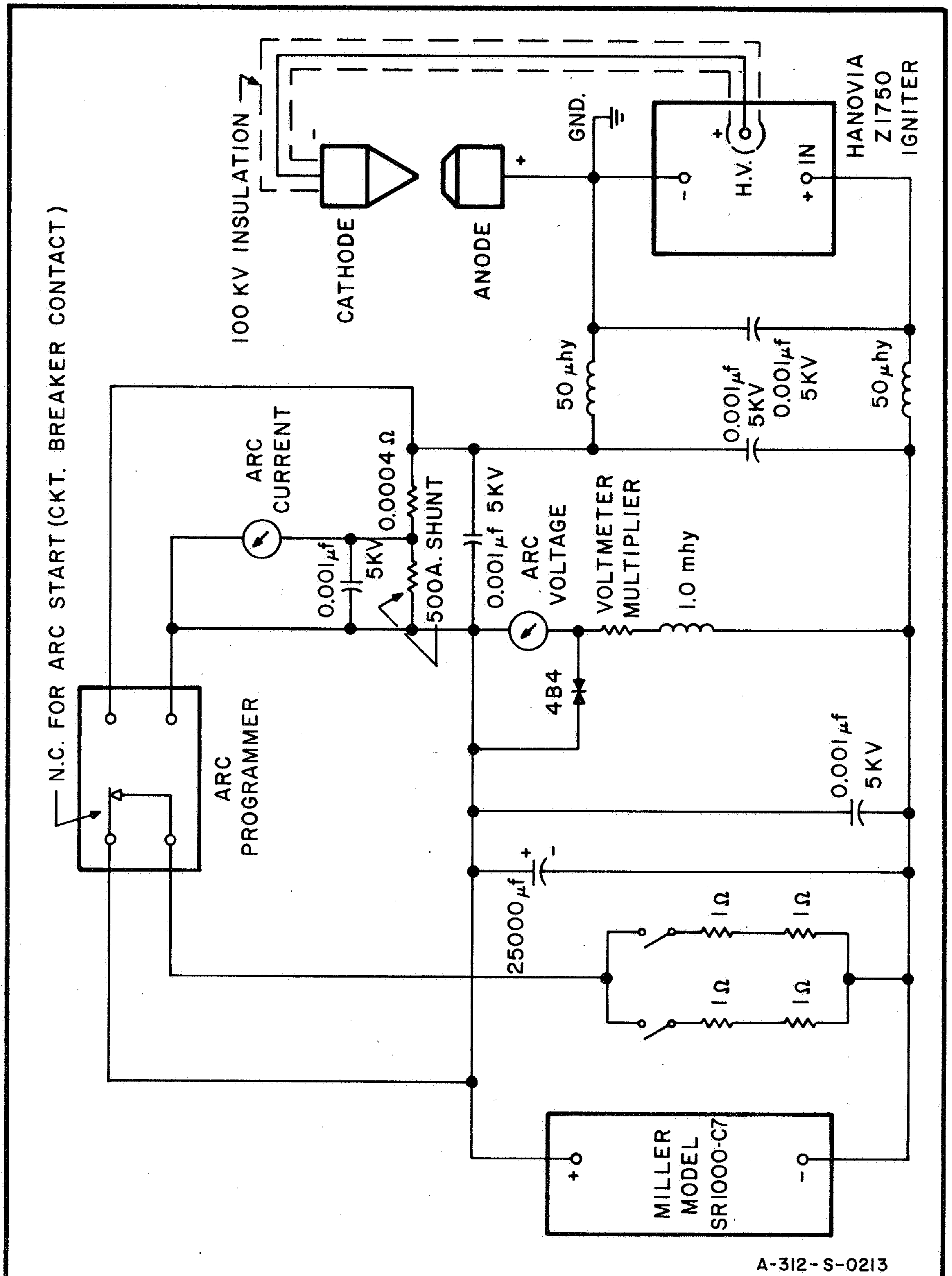

FIG. 9 POWER SUPPLY AND STARTING CIRCUIT FOR FTA RADIATION SOURCE

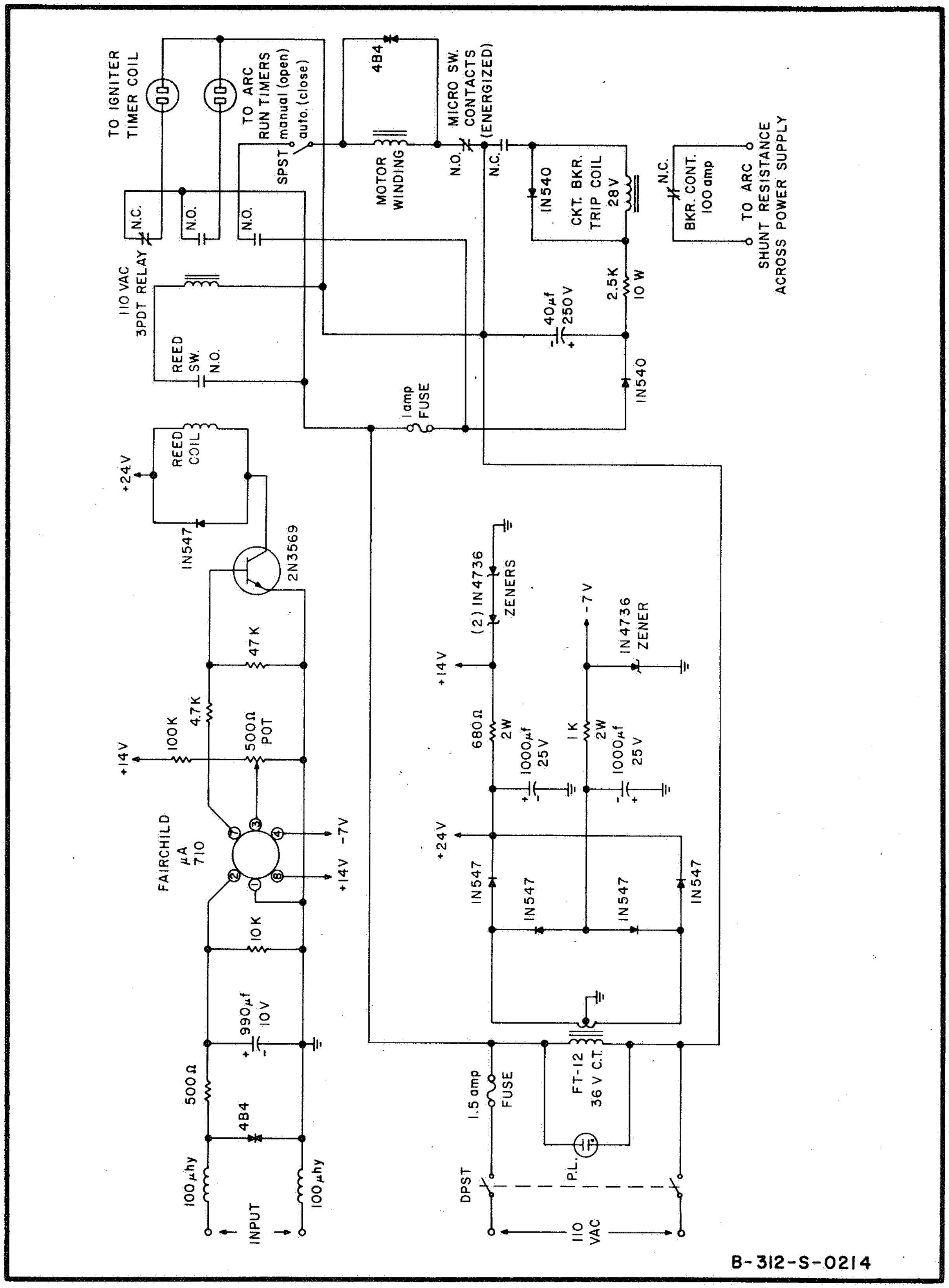

FIG. 10 ARC PROGRAMMER

ignition current,* and is limited by the required back-up open circuit voltage necessary to start the arc by spark ignition with a fixed inter-electrode gap. The control of the current rise from minimum is achieved by an adjustable programmer shown in Fig. 10. This unit contains an integrated microcircuit, whose function is to match the current input to a fixed pre-set value, driving a servo motor which raises the arc current until the pre-set value is reached, whence a circuit breaker cuts the entire unit and shunts out of the system. Manual over-ride is provided for final adjustment of the steady state current level, which may be raised if desired.

This system has been found to operate satisfactorily with tungsten porous anodes made from close-packed sintered spherical powders of classified mesh sizes from 40/60 to minus 325, without any melting.

Manual adjustments are made by viewing the image of the arc on the ground glass screen on the control console, to obtain the desired configuration of opposed arc flames. This factor is being studied from the standpoint of stability, as well as optimum radiance, gas flow rates, pressure, and current density.

Radiometry

The basic configuration for measurement of spectral distribution of radiance of the source is shown in Fig. 11. This follows the methods of Stair and co-workers.[2] The components are as follows:

---

* A more sophisticated way of accomplishing the same result without reducing the back-up voltage is to utilize a specially designed saturable transformer in the main power supply. This would eliminate the need for the shunt resistors and make available the full open circuit voltage for arc ignition. This was not used here because of the expense involved in a custom-designed power source.

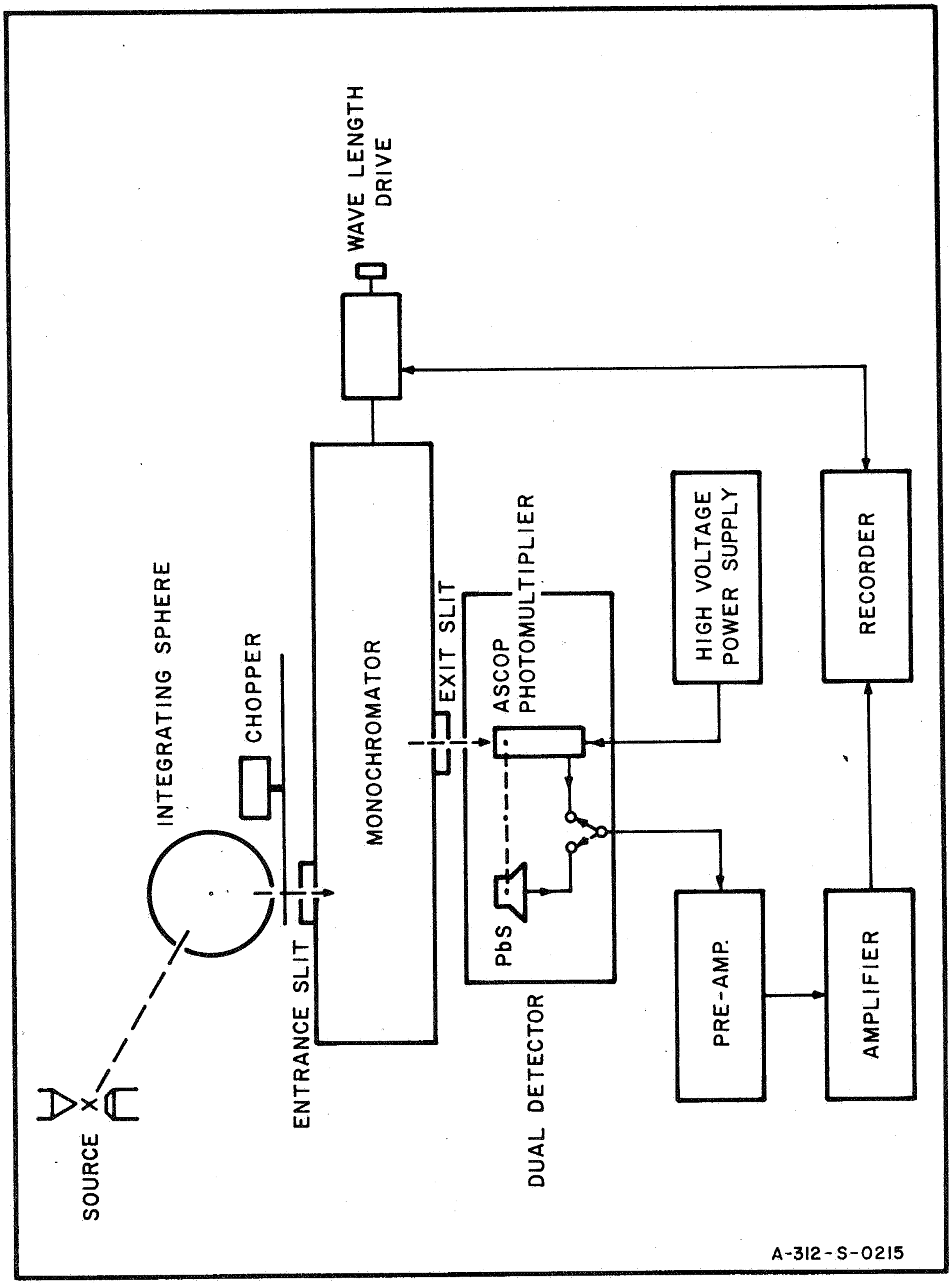

FIG. 11 SCHEMATIC RADIOMETRY ARRANGEMENT

Integrating sphere: This unit was produced in-house following the method kindly related by personnel of the Thermophysics Laboratory of Goddard Space Flight Center. The interior was coated with magnesium oxide, deposited from the flame of a burning magnesium metal ribbon under the action of a high voltage field.

Chopper: This is a Brower 500 cps unit.

Monochromator: Carl Leiss double prism unit.

Dual Detector unit: The sensing units are

1. For wave length range .65 to 2.5μ - PbS matched-resistance Kodak Ektron detectors, mounted in an EG&G Thermoelectric Temperature Controlled Module, Model 1301-1C-R-F;

2. For wave length range .25 to .65μ - Ascop Photomultiplier Model 541E, powered by:

Power Supply: Power Designs Inc., Model HV-1556

Pre-amplifier: Brower Model 261

Amplifier: Brower Linear Amplifier Model 131.

Recorder: Houston Omnigraphic Model 6520.

Wave Length Drive: In-house assembled motor drive and gear train synchronized to match recorder interval sensitivity required for a three-minute traverse over the wave length range of interest.

Current Test Work

During the interval reported upon, ending December 31, 1967, the details of the ignition transient were studied and the solution of the problem related to reliability and integrity of the anode was worked out, as summarized in an earlier section under auxiliary development work.

In addition, the assembled system was tested for pressure operation, without striking the arc. During this series of tests, the pressure was progressively raised and maintained for daily intervals. The quartz envelopes which were tested were purchased on the basis that they were capable of withstanding a steady pressurization to 450 psi with a safety factor of 3. However, one set exploded under cold pressurization at 400 psi after several hours at that pressure; this represented a failure of the outer envelope, which is the thicker one and which must withstand the pressure differential. In view of this result, and after consultation with the vendor (Tamarack Scientific Corp.) it was decided to limit the pressure during the forthcoming period to the range 50 - 200 psig, and to consider higher pressures later.

During an initial run with the arc at 50 psig, it was observed that edge leaks of gas occurred at the border of the tungsten anode in its copper holder. This disturbed the symmetry and energy transfer of the arc.

This condition was corrected by specifying closer tolerances on the porous sintered tungsten plug diameter, and shrink-fitting the plug into a semi-machined copper holder, which was bored out to pre-calculated diameter, designed to furnish close clearance with the plug when hot, and then cooling it for finish machining. This produced tight fits without edge leaks, as deterimned by flow scanning across the anode surface with a miniature pitot tube coupled to a very sensitive pressure transducer in a configuration developed in this laboratory for arc diagnostics in another previous program.

III. PLANS FOR THE NEXT PERIOD

1. Determine ignition conditions (gas flow, starting current, rise time to steady state, and power levels).
2. Evaluate these conditions at step intervals in the range 50 - 200 psig.
3. Determine steady state operating conditions for progressive power and pressure levels.
4. Measure total radiant power.
5. Optimize operation at 200 psig.
6. Initiate spectral irradiance measurements.

IV. REFERENCES

1. Sheer, C. and Korman, S. "The Fluid Transpiration Arc as a Radiation Source for Solar Simulation." Semi-Annual Progress Report P-3/312. AFOSR 67-2363. January 1, 1967 - June 30, 1967.
2. Stair, Ralph, Johnston, Russell G., and Haobach, E.W., "Standard of Spectral Radiance for the Region of 0.25 to 2.6 Microns." J. Res. N.B.S., 64A, 291 (1960).

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Columbia University Electronics Research Laboratories New York, New York 10027	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

THE FLUID TRANSPIRATION ARC AS A RADIATION SOURCE FOR SOLAR SIMULATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Scientific - Interim Progress Report (Semi-Annual) covering period July 1 to Dec. 31, 1967.

5. AUTHOR(S) (First name, middle initial, last name)

C Sheer and S Korman

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1 March 1968	27	2

8a. CONTRACT OR GRANT NO. AF 49(638)-1395	9a. ORIGINATOR'S REPORT NUMBER(S) P-4/312
b. PROJECT NO. 9783-02	
c. 6144501F	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d. 681307	AFOSR-68-0762

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
TECH, OTHER	AF Office of Scientific Research 1400 Wilson Boulevard (SREM) Arlington, Virginia 22209

13. ABSTRACT

This report covers the period July 1, 1967 to Dec. 31, 1967, and is the second in a series of progress reports on a project to develop the fluid transpiration arc as a radiation source for solar simulation. Continuing with the colinear opposing flow geometry of the two electrode columns, a complete module has been designed, constructed, assembled and instrumented for operation and for analysis of radiation and energy dissipation. Work was also begun on assembly of spectral irradiance instrumentation.

Preliminary testing disclosed two basic problems, requiring effort directed toward auxiliary development. These problems were (1) maintenance of the integrity and porosity of the tungsten porous anodes, specifically to avoid destruction or deterioration of the surface by melting; (2) the need for a porous tungsten anode design which would ensure that all of the gas metered to the anode would enter the arc discharge--a requirement which was particularly acute at pressures above atmospheric. Both problems were successfully solved and the results incorporated into the program. In particular, the first problem was solved by introducing circuitry which would control the arc ignition transient current level. The second problem was solved by shrink-fitting the porous slug into a precision-bored copper holder; when properly done, this eliminated edge-leaks.

DD FORM 1 NOV 65 1473

Security Classification